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# SCIENCE

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## ANIMAL MORPHOLOGY IN ITS RELATION TO OTHER SCIENCES.

IN the system of classification adopted by the organizers of this congress the science of animal morphology is apparently to be defined so as to exclude comparative anatomy. I take it, consequently, that it is intended to include only the broader problems connected with the form of animals—such as the phylogenetic evolution of form, the embryological development of form and the restoration of the mutilated form—in general, the form-producing and form-maintaining factors.

Expressed in this way the relations of animal morphology become more evident; and clearly the first and most intimate of these relations is with the morphology of plants. The separation of animal morphology from plant morphology in the department of biology, while according with a division of the subject found to-day in our universities, is, I think, not an ideal condition. For the form-producing and the form-maintaining factors are, at bottom, the same in all organisms. The problem of what factors have worked to determine whether a fish or a man shall have such and such a form is identical with that of the determination of the form of a fern or an oak. Little by little the morphologists that deal with the broader aspects of their science are being forced to face the absurdity of its division on the basis of the material studied. In cytology it is found that the maturation of the germ-cells, the fertilization of the egg and cell-divisions, are identical processes in the two 'king-

doms.' To admit a plant cytology and an animal cytology is only less absurd than to admit a mammalian cytology, an avian cytology and a reptilian cytology.

What is true of cytology is true of the other branches of morphology such as embryology in its broadest sense, the phenomena of regeneration and regulation in organisms, and especially the evolutionary history of specific forms. While in taxonomy we must continue to have botanists and zoologists, as we shall continue to have ornithologists, entomologists, etc., yet outside of the purely descriptive subsciences I would the gulf between botanists and zoologists were annihilated and that we had biologists separated rather in regard to *subjects* and university chairs, journals and societies devoted to evolution, cytology, ontogenetic processes and form regulation without regard to the systematic position of the material studied. Then we might hope to advance a subject instead of mulling over endless descriptive details.

We have next to consider the relations of morphology to form evolution or phylogeny. Before we can consider how a new form arises we must clear the field by seeking some element of form. The mass of material in the organic, like that in the inorganic, world early led to an attempt at the classification of these materials in both biology and chemistry. In chemistry a certain number of kinds of materials have in course of time been catalogued and are called substances, each of which has its particular *molecular* composition. In biology likewise many thousand kinds of organisms have been catalogued, and these are called species, each made up of particular sorts of *individuals*. Chemistry has gone a step further in its analysis of inorganic matter and recognized that the different molecules are made up of diverse combinations of a relatively small number of units called atoms. To-day biology has

to recognize that its individuals are likewise diverse combinations of units—relatively very numerous—which, following de Vries, we call unit characters, or we may use the simpler name of 'characteristics.' Characteristics are thus to individuals what atoms are to molecules. As the qualities and behavior of molecules are determined by their constituent atoms, so the essence of the individuals of any species is determined by its constituent characteristics. And as we may construct new substances at will by making new combinations of atoms, so we may produce new species at will by making new combinations of characteristics. The making of new combinations in molecules or species is a useful work, but it is not evolution. Evolution in the inorganic or the organic world is first achieved when we can make new atoms or new characteristics, as the case may be.

This conception of species, which has arisen during the present decade, has its germ in the work of Mendel, and in consequence of the stimulating researches of de Vries, Correns, Tschermark, Bateson and others has developed into a stately doctrine, a doctrine which bids fair to revolutionize biology as the atomic theory did chemistry. It adds at once a new dignity and interest to morphology as well as to the description of species or taxonomy. In describing the form of an animal we are enumerating its qualities. Many of these are directly the unit characters of the species; others are composite and may be analyzed, by appropriate methods of breeding, into the elemental characteristics.

I may illustrate this by reference to domesticated poultry, to which I am now paying some attention. It is impossible to enumerate all of the characteristics of poultry, but the following are some of the most striking:

Size: Large and dwarf, which are ex-

emplified in the Asiatic breeds and the bantams.

Colors: Black; buff or red; white; brown (in the female) the male being often bronze, green, black, yellow and white; barred (as in the Plymouth Rock) and spangled (having center of feather of different color from periphery).

Comb: Single, pea, rose (flat, covered with tubercles, like a file); replaced by crest.

Legs: Feathered, featherless; black, blue, yellow, horn color.

Body shape: Short and chunky; tall and slender.

Now the various varieties of fowl are made up of various combinations of these characters. Thus we may have Plymouth Rocks which instead of having bars are pure white, or all buff; or the single comb may be replaced by a rose comb (when they are called Wyandottes), the usually clear legs may be feathered, and, finally, they may be 'bantamized.'

Any desired characteristic in the whole catalogue of poultry characteristics might be engrafted upon an original Plymouth Rock stock. We might put on it the crest of the Polish fowl or the twisted feathers of the frizzle, or the loose barbs of the silky, or the taillessness of the rumpless or the long tail feathers of the Japanese long-tailed fowl. All this is of course possible because of the cross fertility of the races having these different characteristics. By similar procedure we might make a white, blue-eyed, deaf, long-haired, tailless, seven-toed cat; engraft the horns of the Dorset sheep upon the hornless Southdown; add the fecundity of the two-nipped horned Dorset to the multinipped condition of Dr. Alexander Graham Bell's flock. We might expect, after some experience, to do this with the same certainty that we can get calcium chloride and car-

bonic acid out of a mixture of hydrochloric acid and marble.

The bearing of this illustration, I repeat, is to show us that characteristics of species are entities not a little of whose interest lies in the question of their origin in each case. When we know how such characteristics arise, then we may call them forth at will and so determine the evolution of organic form. For the present it is sufficient that by the acquisition of new characteristics new species have arisen from preceding ones.

This assertion is justified by the examination of any extensive synopsis of species. Take, for example, de Bormans's synopsis of Forficulidae in 'Das Tierreich.' Take any synoptic key at random. *Apterygida japonica* has two large tubercles at the end of the abdomen. *Apterygida allipes* has four small ones. *Anisolabis xenia* differs from *A. littorea* by slightly smaller size and especially by having two teeth in the forceps in the male or three in the female instead of none at all. I do not mean to assert that species have arisen *only* by an addition or subtraction of characteristics, but this is a common method. Very often we find one characteristic being replaced by another. Thus in Lepidoptera one species may differ from another in the replacement of red by yellow; or one earth-worm will differ from another by having the sexual openings in different segments. We have no reason for thinking that these characteristics are not integral entities as much as those distinguishing domestic races. The modern morphologist, therefore, with the significance of characteristics in mind must appreciate that in enumerating these characteristics he is enumerating the steps of evolution.

The relations of morphology to embryology are so intimate that the latter is commonly reckoned a subdivision of the former. Certainly the interpretation of the

adult form depends on a knowledge of its development. 'In terms of the ancient riddle,' says Bateson (*Nature*, Vol. 70, p. 412) in his recent address as president of the section of zoology in the British Association, 'In terms of the ancient riddle we must reply that the owl's egg existed before the owl, and if we hesitate about the owl we may be sure about the bantam.' The characteristics of the adult form are implicit in the fertilized egg and are determined by the Anlagen of the characteristics wrapped up in that egg. We know now that upon the symmetry of the egg and of the successive cleavages often, if not typically, the symmetry of the adult form depends, and that upon the lack of symmetry of cleavage in Gastropods their lack of symmetry is probably to be referred. In the successive cleavages definite organ-tracts are marked off and still later the epidermal organs, such as hair, feathers and scales—the bearers of the more evident heredity characteristics—are laid down in regular lines radiating often from single points or groups of cells, thus simplifying the problem of inheritance of peculiarities of plumage or coat color by referring them back to transmission through particular cells or cell groups. It has thus been possible to show that all the numerous dorsal appendages of the nudibranch mollusc *Eolis* are derived from material split off in a regular manner and at regular intervals from a group of cells lying in the tail end of the developing animal. Thus the interpretation of the mechanism of transmission of qualities is first gained from a study of embryology.

A second way in which embryology has been regarded as indispensable to morphology is in the light it has thrown on homology. By homology—the will-o'-the-wisp of morphology—is meant such a similarity of unlike things in different species as would justify their receiving the same

name. And one of the strongest grounds of a homology is similarity of origin regardless of function or even ultimate anatomical connections. The search for homologies has led to the idealization of the 'type,' and this more than anything else has blinded morphologists to the facts of variation and evolution. When, however, twenty-two vertebræ in place of twenty-one can nonplus the seeker after homology, its ethereal nature is sufficiently indicated. Homology may, indeed, exist between normal types, but the abnormal or pathological is often beyond homology and yet just the abnormal is, paradoxical as it may sound, the important for evolution.

As we study an organism's form we see that it is not made up merely of a great number of characteristics, but that these characteristics are, on the whole, such as enable the animal to thrive in its environment. We are struck by their 'adaptive' nature.

I am well aware that twenty years or so ago this side of morphology—the side, namely, of the accounting of an organism's form on the ground of use—was little cultivated. Morphology had for its aim the discovery of the interrelation of parts in the individual organism and the homology of parts in different individuals or species, and if it sought to go further it indulged only in speculative inferences as to the probable function of the parts. On the whole the student's attention was directed towards connections of organs and his natural inquiry as to use was stifled. Some one said that function varies while the form persists. This phrase became a dogma and function was considered a matter too trivial for consideration. Homology was the study for men of science; analogy was for the dilettanti. Morphologists should have been warned by cases like the whale whose teeth can not be homologized

with those of other mammals, and not have underrated the limitations of homology nor the importance of the study of adaptations. Only within the last few years have we come to recognize that every organ is more than a homologue: it is also a successful experiment with the environment.

The existence of that relation between form and environment which we call adaptation has been recognized for centuries, yet its full significance is still obscure. The prevailing theory (of Darwin) assumes that a change in environment precedes any change in form and that adaptation is, therefore, necessarily achieved by a change in the mean of the form to meet the changed demands of the new environment. This theory may, indeed, be said to be the natural outcome of the morphological doctrine of fundamental fixity of type. The type could be bent to meet new conditions, but could receive nothing new nor suffer loss of parts. I find that in the pre-Darwinian epoch Prichard suggested that the creator made the various species and placed them in habitats for which their structure fitted them. We see in this suggestion translated into modern terms the germ of a very different theory of adaptation from the prevailing one. I expressed this nearly two years ago about as follows: "The world contains numberless kinds of habitats or environmental complexes capable of supporting organisms. The number of kinds of organisms is very great; each lives in a habitat consonant with its structure." Each species is being widely dispersed while, at the same time, it is varying or mutating. By chance, some variants of the species get into an environment worse fitted for them; others into one better fitted. "Those that get into the worse environment can not compete with the species already present; those that get into a habitat that completely accords with their organization will probably thrive

and may make room for themselves, even as the English sparrow has made room for itself in this country. This process may go on until the species is found only in the environment or environments suited to its organization. As Darwinism is called the survival of the fittest organisms, so this may be called the theory of segregation in the fittest environment."

The principle that animals are found in habitats for which their structure fits them, and not elsewhere, points to the close relation existing between morphology and geography. We find the animals of the seashore, such as sponges, Hydro- and Anthozoa, and tunicates, to be largely sessile, and in consequence, of the radiate type of structure. This sessile habit makes it possible for them to maintain their hold on the rocks from which the beating waves tend to tear them. Those which are not actually permanently attached have means enabling them to cling closely to the rocks; such are the echinoderms, the molluscs, many annelids and crustaceans. The animals of the surface of the sea, such as siphonophores, etenophores, jelly fishes and larvæ, are without such clinging organs; they include species whose organization permits them only to float or swim at or near the surface. The deep sea could have been populated more readily, so far as proximity goes, from the surface organisms than from those of the shore line; but only the latter offered the structural features consonant with life at the sea bottom and so the deep sea became populated thence. In the swift-flowing rivers we find powerful swimmers or animals that can hold fast to the bed of the stream and in ponds we find those species which have some means of preserving their continuity in time of drought. In caves we get not any forms which happen to be washed into them, but only darkness, moisture- and contact-lovers. In deserts whole groups of

animals are absent, only those occurring with thickest skin—least apt to lose water by transpiration—such as certain snakes, lizards and hard-shelled beetles. In general, in studying the geographical distribution of animals in environments presenting extreme conditions we find that they clearly have been selected from groups presenting the most favorable characteristics. All of this indicates that, often at least, the already existing morphological conditions have determined the fitness of a species to cope with the environment—morphological characteristics have determined geographical and climatic distributions.

Morphology as the science of form is often contrasted with physiology, the science of function. Yet between the two is the closest possible relation, because an organ implies a function and every morphological characteristic has a corresponding physiological characteristic. As physiological characteristics are transmissible in the same way as morphological, we may think of any individual as being made up of such functional characteristics, just as a molecule is made up of atoms, and in the transfer from one race or species of a set of morphological characteristics we transfer likewise the corresponding set of physiological characteristics. Thus to return to poultry, we find the rate of growth, the age at maturity, the egg production, the brooding instinct and the resistance to disease to be characteristics of various races, and it is quite possible to combine such characteristics—in so far as they are not incompatible—in various ways. Thus we have poultry that mature early, lay many eggs and are not broody—of these the white Leghorn is a good example. Or, we may have poultry that grow large, mature late, lay throughout the winter and are very broody—such are the Cochins. This similarity in capacity for making combinations which we see between phys-

iological and morphological characteristics proves their close kinship and the unscientific nature of the division which would relegate their study to distinct sciences.

What is true of domesticated races is true also of wild species. Biology has suffered from the circumstance that species have been studied almost exclusively from dead specimens. Attention is focussed on proportions in the dimensions of bones, on number of spines, on antennal joints, on shell markings and so on, and we seem to have overlooked entirely the fact that all these characters constitute only one face of the shield. The structural descriptions of the systematist give us a no more adequate idea of the characteristics of species than does the sight of this exposition on a Sunday when all wheels are stopped and only the form, beautiful and grand as it is, remains give us an adequate idea of it. And so in the study of species we can not understand the form characteristics without considering also the function characteristics. I may illustrate this by some studies which Miss Smallwood has been making at Cold Spring Harbor. She started with a species of Amphipoda—*Talorchestia longicornis*—that lives on the beach where it is rarely covered by the tide. After studying its form and behavior for several months she investigated a second species of the same family of Orchestidae, *Orchestia palustris*, that lives on the salt marsh to the limit of the highest tides. After studying this for some weeks with respect to behavior correlated with structure she has begun on still a third species of the same family, *Alorchestes*, which is a typical aquatic organism. The instructive thing that comes out of her studies is that in just the same way as these species differ in structural characteristics they differ in functional characteristics and the two kinds of differences go hand in hand and they have to be studied together to be fully intelligible.

In still another way are the dynamical and static characteristics bound together, for every form or part has not merely a form or function, but a development, and development is a dynamical process. A decade or two ago embryological development was regarded as a purely morphological subject, as a series of stages, and little attention was paid to the causes that produce the stages and the succession of organs. During the last decade, however, partly under the stimulus of physiologists who have entered the field of embryology, its dynamical problems have been studied also by morphologists. As a result of the researches of Loeb, Driesch, Herbst, E. B. Wilson, Morgan and many others we have come to recognize that the egg is organized—cytoplasm as well as nucleus—and that it exhibits varying degrees of organization in different cases. Sometimes it seems as though every part of the egg was totipotent, as in the medusæ; in other cases, the different parts of the cytoplasm seem told off to develop into particular and definite organs, as in some molluses. We have learned, further, that at every stage new organs are called forth and their development directed by stimuli proceeding from already existing organs.

Moreover, it has been found that even adult structures are dependent upon external conditions for their form. It appears that peculiar functioning may alter the form of internal organs, as has been demonstrated in the case of a ship's trimmer and of a cobbler by Lane, and as a vast number of pathological cases testify, such as the alteration of the arrangement of plates in the spongy tissue in the head of the femur, and the functional hypertrophy of the other kidney after the loss of one. Morphologists have been forced to realize that form and structure can not be dealt with aside from function and behavior. Every part of the living body is a sensitive

responding part whose sensitiveness determines structure. This is seen particularly well when the body is mutilated or a part removed; then begins the wonderful process of regeneration or regulation by which, under control (in the higher animals) of the nervous system, the lost parts are in many cases restored. In truth, the work of the morphologist has extended into the realm of the form-developing and form-maintaining factors and this is a physiological realm.

From these experiences I conclude that the morphologist who studies form characteristics only is too narrow. *Characteristics* in their twofold aspect of form and function should be the object of his investigations—their difference in allied species, their integrity, their behavior in breeding, their phylogenetic origin, their embryological development and their maintenance in the adult.

Morphology has relations with sciences quite outside of biology. I have already insisted that the problems of form and structure are also physiological problems, but in last analysis they are, I think, problems of physics and chemistry. For myself, I have no doubt that we shall some day be able to prove that each characteristic of an organism depends upon a specific substance in the germ cell, and we may hope by altering this substance experimentally to change the corresponding characteristic. Such a change is mutation and mutation in last analysis, as de Vries maintains, depends upon external conditions.

Apart from this it is certain that the physiological processes involved in the individual's characteristics are modifiable and, indeed, controlled by physical agents in the environment. Thus it has been possible to show that certain salts play special rôles in the development of particular organs or characteristics (Herbst). Loeb, indeed, has shown that regeneration of

hydroids does not occur in the absence of potassium. We know, likewise, that iron is necessary to the formation of the chromatin of the nucleus.

The physical conditions have likewise an influence in morphogenesis. The rate of development is controlled within limits by temperature. The number and position of stomata and of leaves by light and moisture; the number and form of plant hairs by moisture; the position of branches and leaves on a stem by gravity; the formation of a hydranth in a hydroid stock by light. So evident is this dependence of morphogenesis upon physical agents that two individuals of the same family develop alike only under the same conditions of environment.

There remain to be considered the relations of morphology to the queen of the sciences—to mathematics. Until recent years little relation has been recognized, and this I attribute to the fact that few naturalists have a type of mind that attracts them to mathematics. They have usually been led to their science through a love of nature—a passion that belongs rather to the poetic type of mind than to the severely precise mathematical. And so I find that, even to-day when the bearing of mathematics on morphological problems can not be overlooked, few morphologists take an interest in the subject of biometry by which the two sciences are connected.

The fact that few morphologists have little taste for mathematics can not stay the inevitable trend of the science toward greater precision of expression and toward mathematical analysis. Until recent years characteristics have been described only in the crude language of adjectives and adverbs—where greater precision is necessary quantitative expression is inevitable. So we have seen during the past ten years the rise of biometry and its application to

many morphological problems. Biometry had its beginning in the suggestive investigation of Galton; its great development in the last ten years has been due, above all, to the tremendous activity of Karl Pearson and the workers he has gathered about him. By the aid of efficient methods of analysis we are able to state quantitatively not only the mean value of any measurable characteristic, but also the degree of its variability and the closeness of associated variability of two interdependent organs. Moreover, it is possible to study the nature of the variability exhibited by any characteristic in any homogeneous lot of individuals and to draw an inference from the nature of this variability—as exhibited in the variation polygon—concerning the condition of the characteristic in question in the given race. A person of experience can tell from a glance at the variation polygon whether the race is in a condition of equilibrium so far as this characteristic goes, or whether it is breaking up into several forms or is, perhaps, evolving into some other condition. The quantitative expression gives a means of measuring change of the mode from epoch to epoch which Weldon used in studying the crabs at Plymouth and which enabled him to demonstrate a progressive change in form. It gives also a means of measuring the alteration of an organ in different environments and so of estimating the effects of changed external conditions. Thus it has been shown that the modal number of ray flowers in the ox-eye daisy depends upon the conditions of nutrition in the soil; the chela of the male crab, *Eupagurus*, is relatively smaller in deep water; the mud snails, *Nassa*, of brackish water are depauperate.

Again, mathematical methods have given us a measure of the correlation between organs, so that the exact relation between human stature and the length of a long bone being known, the stature of extinct

races may be calculated from a collection of disinterred femurs. Pearson has been able to show that there is no correlation between shape or size of the head and intelligence, and to demonstrate the efficiency of vaccination and the non-inheritableness of cancer. The opinion that various bodily characteristics are bound together has been substantiated by studies in the correlation of all sorts of organs in plants and animals and the degree of this correlation measured. This index of correlation measures the degree of morphological kinship or of physiological interdependence. Symmetry gains a quantitative expression and it is interesting to find that originally non-symmetrical organs which have secondarily gained antimeric relations—as in animals that habitually lie on one side—gain a very high index of correlation. Thus I find in the scallops (*Pecten*) which are lamellibranchs that have come to lie on the right side the index of correlation between the dorso-ventral and antero-posterior diameters is 97 per cent., whereas the correlation between the breadths of the right and left valves is only 86 per cent. As heredity is only one phase of correlation, the inheritance of characteristics can, by the new methods, be exactly measured. It is demonstrated that there is such a thing as prepotency of one parent and that heredity is weakened by change of sex. It is shown that mental and physiological characteristics are inherited exactly like morphological characteristics; and that the relationship between the leaves of a branch or the zooids of a colony is like that between brothers of a family. We learn that all inheritance is not all of one kind. That certain characteristics, like stature and skin color, blend in the offspring; while others, like the coat color in mice, refuse to blend and may be inherited according to Mendel's law:

By mathematical analysis the selection

of particular characteristics, or those of a particular degree of development, has been demonstrated and the exact effect of the selection process upon the frequency polygon has been made clear. Extreme variants are often annihilated, although in other cases the position of the mode is shifted. Finally, through quantitative studies the existence of local races has been clearly proved—the degree of their differentiation and its dependence on environmental conditions has been measured. It has been shown that a characteristic does not remain the same in all localities and under all conditions, but may become slightly altered. This fact speaks strongly for the contention that new species may in some cases have arisen by the summation of infinitesimal differences—that not all evolution is by mutation.

In concluding this address I am impressed by the fact that to-day any science ramifies in all directions toward every other. There can be no doubt that the most fruitful work in any science is to be done in the border line between it and some other science. There is another corollary to this close interweaving of the sciences and that is that the existing classifications have become antiquated. Our university departments, our societies and our journals still, for the most part, draw the old lines. Yet the true work of science has, I apprehend, overleaped the barriers of these classifications, and the best workers will in the immediate future be no longer botanists or zoologists, or chemists or mathematicians, but will be interested in particular subjects—in following some favorable lead into the unknown. The embryologist who is interested in processes, the cytologist who is interested in the fertilization of the egg will feel free to work on any material, whether plants or animals or crystals or colloidal mixtures—and by any methods that seem likely to be of aid

to him. And I hope to live to see the day when our now overgrown zoological and botanical societies shall languish while groups of men devoted to a common subject and investigating it with the most diverse material will meet together to discuss results of common interest. When a subject no longer demands vigorous investigation and the center of activity is shifted elsewhere I should like to see the old associations abandoned and new ones formed to advance the newly risen problems. Our large societies are a hindrance, I sometimes think, rather than a means of advancement to science. We want smaller meetings with more acute interest. And, finally, I can not but remark on the vastness of the preliminary training which the present ramifications of every science make necessary. Research in the fields between the old sciences has rewards for the investigator, but he who would reap those rewards must prepare himself through years devoted to gaining the mastery of many sciences.

CHAS. B. DAVENPORT.

COLD SPRING HARBOR, N. Y.

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*THE PROBLEMS OF INTERNAL MEDICINE.\**

To recognize, to prevent, to protect, to heal—these are, in the broadest sense, the tasks of internal medicine now as ever. But how different are the problems which occupy our attention to-day from those of the period commemorated by this congress. Let us for a moment glance back at the medicine of the close of the eighteenth and the beginning of the nineteenth centuries. For over two hundred years the blind and binding faith of the middle ages, the faith that had so long fettered the human mind, had been slowly giving way before the

forces of reason and truth. Now and again with ever-increasing frequency, great and courageous minds had risen above the clouds of medical tradition and dogma, which had smothered the understanding and reason of mankind, as if, indeed, medicine were a part of the religious doctrine which ruled the world. For truly the medicine of the middle ages was largely a matter of faith, and as a matter of faith one in which reason beyond a certain point was heresy and sacrilege. Vesalius with genius and courage had begun to withdraw the veil from naked and iconoclastic truth. Harvey had made his great discovery. Glisson had demonstrated his theory of irritability. Mayow with his 'Spiritus nitro-aereus' had anticipated the discovery of oxygen. Leeuwenhoek and Malpighi and Hooke had opened to the human eye the realm of the infinitely small. Bacon and Descartes and Newton and Locke had introduced into the world a rational and natural philosophy. Locke, himself, indeed, a wise physician, had pointed clearly to the true path of medical progress. "Were it my business," says he, "to understand physick, would not the safer way be to consult nature herself in the history of diseases and their cures, than espouse the principles of the dogmatists, methodists or chymists."

But the clouds of medical tradition were slow to clear away. Gradually, however, the first 'lonely mountain peaks of mind' had been followed by an ever-increasing number of earnest and untrammeled students. In the seventeenth century the opportunity to give one's life freely to the search for truth had become more and more open to all. The mysticism and animism of Stahl which, in the early part of the eighteenth, hung over the medical world, was already breaking away. The study of the natural sciences was pursued more eagerly and generally than ever before.

\* Address delivered before the Section for Internal Medicine of the International Congress of Arts and Sciences, at St. Louis, September 22, 1904.